

## **INTRODUCTION**

Putrajaya is a city planned and built to meet the challenges of the new millennium. It is A City in a Garden that turns to nature for inspiration, resulting in a landscape dominated by the picturesque Putrajaya Lake. A high standard of lake water quality is one of the most important factors for the success of this scenic centerpiece, and the solution was found in simulating yet another gift of nature - with the construction of Putrajaya Wetland.

Malaysia's new Federal Government Administrative Centre of Putrajaya is not just a new city. It also represents the coming-of-age of Malaysia as a dynamic and progressive member of the global community committed to the concept of sustainable development

## **WETLAND DEFINITION**

Wetland are defined by the Convention of wetland of International Importance (the Ramsar Convention 1971) as; "Land inundated with temporary or permanent water that is usually slow moving or stationary, shallow, fresh, brackish or saline, where the inundation determines the type and productivity of soils and the plant and animal communities".

## **THE ROLE OF WETLAND**

The role of wetland in water resource management is fast gaining ground resulting in the construction wetland in most developed countries. Constructed wetland are man-made system that involves altering the existing terrain to simulate wetland conditions. They primarily attempt to replicate the treatment that has been observed to occur when polluted water enters the natural wetland. These wetland have been seen to purify water by removing organic compounds and oxidizing ammonia, reducing nitrates and removing phosphorus. The mechanisms are complex and involve bacterial oxidation, filtration, sedimentation and chemical precipitation.

Most constructed wetland attempt to imitate the ecosystem's biochemical function as filtration and cleansing agents, followed closely by the hydrological function that is centred on flood mitigation.

## **WETLAND FUNCTION**

The use of constructed wetland to treat urban surface runoff and remove nutrients from diverse sources in rural catchments has received much attention lately. Thus, wetland are essentially the filtering area, the 'kidneys' of the catchment, intercepting water flow, trapping sediment and pollutants, removing toxic substances (pesticides, herbicides, metals) and assimilating nutrients and energy derived from the upstream catchment area.

Wetland has the ability to filter nutrients from inflowing waters which represent the base of many food chains that not only start and finish within the wetland but extend beyond the wetland complex itself. Where there is food there is life, and hence

wetland act as breeding grounds, nurseries and homes to numerous plants, invertebrates, frogs, reptiles, fish and waterbirds. In fact, wetland are best known as habitats for fish and waterbirds.

Wetland are becoming increasingly popular as ecotourist destinations. Their biodiversity, open space, aesthetics and the development of public amenities make them attractive propositions for passive recreational activities and social pursuit.

It is generally accepted that wetland have the potential to attenuate flooding. Wetland provide retention storage for storm water by spreading the water over a wide flat area. Wetland vegetation retards surface water flow to varying extents depending on the type, density and water depth.

Wetland are a fertile ground for scientific study and research. In fact, there is also a growing interest in wetland among school children who are beginning to embark on a voyage of discovery of their environment by being introduced to this dynamic ecosystem. This may well be the first step in public education of wetland, which are the collective responsibilities of all users.

#### **PUTRAJAYA LAKE AND WETLAND**

The 400 hectares Putrajaya Lake was created by inundating the valleys of Sungai Chuau and Sungai Bisa. The construction was started in 1998 and fully completed in 2002.

The lake has been primarily designed to enhance the aesthetic appeal of Putrajaya. It is also planned to be used for sport and recreation as well as a tourist attraction.

Putrajaya wetland is the first man-made wetland in Malaysia and the largest constructed freshwater wetland in the tropics. It was began to construct in March 1997 and was completed in August 1998. The 197 hectare project resulted in transforming an oil palm site into wetland ecosystem with the helps of modern technology and stringent environmental management methods in design and construction.

The wetland straddle the water courses of Sungai Chuau, Sungai Bisa and three tributaries. Their primary function is to ensure that the water entering the lake meets the standard set by Perbadanan Putrajaya.

To achieve this, the wetland have been planted with a variety of aquatic plants that act as a natural filtration system, removing nutrients and pollutants from the catchment water. They treat natural run-off from the 50.9 sq km Sungai Chuau catchment.



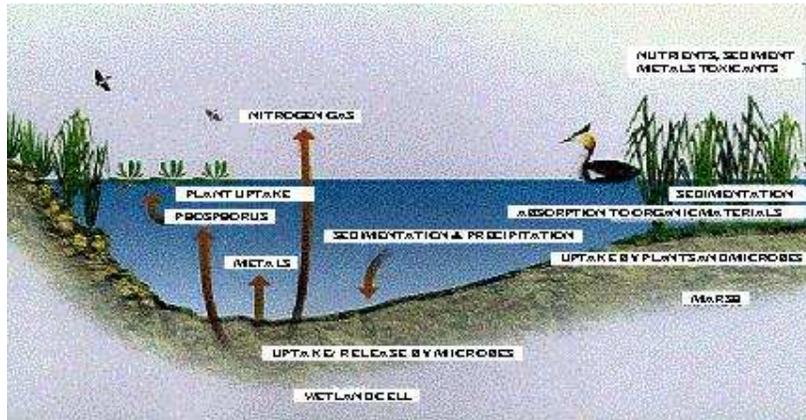


Figure 2 : Various reactions happening in the wetland cells

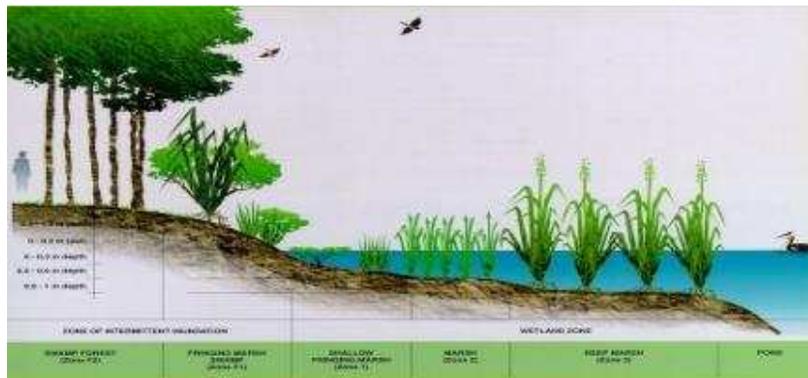


Figure 3: Longitudinal section of a typical wetland cell showing the Zone of Intermittent Inundation (F2 and F1), Wetland Zone (Zone 1, 2 and 3) and the Open Pond

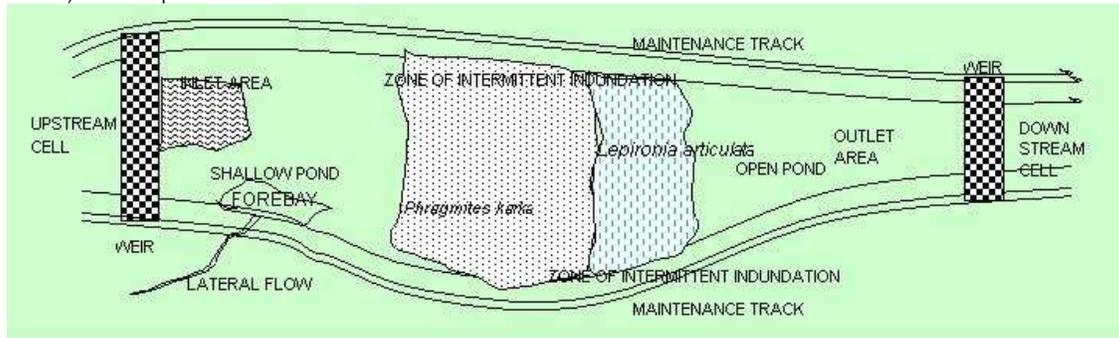


Figure 4 : Typical Layout Of A Wetland Cell

The Putrajaya Wetland cells and its structural components are the keys to the functioning of the wetlands for cleansing the river water. They are important in maintaining the broader 'functional capacity' and objectives of the wetlands, which include providing a habitat for local fauna, primarily mammals, water birds, reptiles, amphibians, fish and invertebrates; hydrological modification (by providing flood detention area and reducing peak discharges and flow velocities) and recreation (the wetlands are used for both

passive and active recreation, and parkland for aesthetic and recreational value).

The principle features of the wetland are shown below :

Principal Features of Putrajaya Wetlands (Area in hectares)					
Total Area	Planted Area	Open Water	Weirs & Islands	Zone of Intermittent Inundation	Maintenance Tracks
197.20	77.70	76.80	9.60	23.70	9.40

Details of the wetland cell structural components and the wetland vegetation species and its proper location within the cell are explained and summarized below :

The Wetland Cell Structural Components And Its Function		
Zone	Component	Functions
<b>Inlet</b>	Inlet	<ul style="list-style-type: none"> <li>Allows water to flow into the wetland cell</li> </ul>
	Energy dissipater	<ul style="list-style-type: none"> <li>Protects the bed of chnnels and inlet and reduces erosion by reducing the energy of incoming water. May be applicable to any part of the wetlands where there are potential erosion problems.</li> </ul>
<b>Macrophyte</b>	Reed beds	<ul style="list-style-type: none"> <li>Waterplants provide support for microbial biofilms which facilitate nutrient transformation, organic flocculation, filtration of pollutants, inhance sedimentation and provide oxygen to sediments.</li> </ul>
	Sedimentation forebay	<ul style="list-style-type: none"> <li>Enhances bacterial decomposition of organic matter.</li> <li>Increases biodiversity.</li> <li>Provides a range of habitats for macro and micro fauna.</li> <li>Provides visual contrast through different textures, sizes, shapes and colours.</li> <li>Enhances settling of finer soil and sediment particles (that would otherwise pass through a GPT) and associated pollutants such as heavy metals, nutrients and pesticides</li> </ul>

		<p>adsorbed by the sediments.</p> <ul style="list-style-type: none"> <li>• Reduces sediment loads to reed beds ensuring higher clarity for effective plant growth.</li> <li>• Improves water quality both within and downstream of the cell and, in turn, the ecosystem health.</li> </ul>
<b>Open water</b>	Open water	<ul style="list-style-type: none"> <li>• Allows UV (sunlight) penetration into the water for disinfection.</li> <li>• Enhances mixing of the water and reduces short circuiting of flows.</li> <li>• Provides a deep water habitat for fauna, refuge during drought, landing and secure area for waterfowl. Meshes into the planted areas thereby enhancing visual beauty.</li> </ul>
	Island	<ul style="list-style-type: none"> <li>• Provides isolated habitats for birds.</li> <li>• Provides a visual focus for the wetlands.</li> </ul>
<b>ZII Zone</b>	Edge water plants	<ul style="list-style-type: none"> <li>• Create habitat diversity along the shoreline for invertebrates and wading birds.</li> <li>• Improve water quality.</li> <li>• Physical barrier to human intrusion to the water.</li> </ul>
<b>Outlet Zone</b>	<p>Water level control structure</p> <p>Trash racks</p> <p>Weir</p>	<p>Allows capture of highly polluted flows for retrieval or recycling. Allows water level control for several purposes including:</p> <ul style="list-style-type: none"> <li>• Operation and maintenance;</li> <li>• Maintaining predetermined water regimes for greater habitat diversity or to specifically encourage particular species of flora/fauna;</li> <li>• Manipulation of water level for waterplant establishment.</li> </ul> <p>Prevent litter and debris entering the cell. Impounds stream flows to create a pool. Sets normal predetermined designed operating water level in wetland.</p>

**The Wetland Vegetation Species And Its Proper Location Within The Structural Components Of A Wetland Cell**

Wetland Structural Component	Typical Water Depth	Vegetation	Typical Species
Shallow Marsh	(~0.3m)	Shallow marshes can be expected to have a regular drying cycle or dry out in some years. Under this type of hydrological regime a diverse vegetation will develop (rushes, sedges and leafy herbs). The actual composition of the vegetation can be expected to change as a response to fluctuations in water level. Vegetation cover can also vary from sparse to dense depending on the species and the water cycle.	<i>Eleocharis spiralis</i> , <i>E. variegata</i> , <i>Scleria cyathophora</i> , <i>Carex indica</i> , <i>Cyperus pulcherrimus</i> , <i>Fimbristylis</i> spp.. A number of dicotyledonous species will also occur in this zone, eg. <i>Clerodendron</i> spp., <i>Lagerstroemia</i> spp., <i>Polygonum</i> spp., <i>Ludwigia</i> spp.
Marsh	(~0.6m)	As depth of inundation and duration increases vegetation diversity tends to decrease. Permanently inundated marshes with water depths greater than 0.6m are frequently dominated just a few species which will often form a very dense cover of vegetation. The actual species will tend to differ from marsh to marsh. However the species that tend to dominate these habitats are nearly always clonal species with large underground rhizomes.	<i>Scirpus mucronatus</i> , <i>Eleocharis dolcis</i> , <i>Scirpodendron ghaeri</i> , <i>Fuirena umbellata</i> , <i>Lipocarpa chinesis</i> .
Deep Marsh	(~1.0m)	As water depth increases the diversity of emergent marsh vegetation is further limited by the size of the plant. To survive in deep water plants must be able to grow to about twice the water depth. The vegetation of deep marshes is generally of medium to sparse cover and dominated by just a few species. The species that tend to dominate these habitats are always large clonal species with substantial underground rhizome systems.	<i>Lepironia articulata</i> , <i>Eleocharis ochrostachys</i> , <i>Eleocharis retroreflexa</i> , <i>Phragmites karka</i> , <i>Phragmites australis</i> .
Pond	(~ 1.5m)	Water depths greater than 1.5m will restrict most emergent aquatic macrophytes and thus result in open water zones. Many submerged and floating	<i>Myriophyllum</i> , <i>Potamogeton</i> , <i>Vallisneria</i> , <i>Nymphaea</i> Weed Risks: <i>Salvinia molesta</i> , <i>Eichhornia</i>

		<p>plants are capable of colonising and growing in this type of environment. Depending on the turbidity it is almost inevitable that this zone will be colonised by some aquatic plants. Regular monitoring of these zones will be required to ensure any invasion of an undesirable weed species is quickly detected and controlled. Colonisation of these zones by acceptable species a benefit as they contribute to enhanced sedimentation and fine particle filtration and provide habitat for aquatic invertebrates and fish.</p>	<p><i>crassipes, Pistia stratiotes, Ipomea aquatica.</i></p>
Wetland Strucural Component	Typical Water Depth	Vegetation	Typical Species
Deep Pond/Sediment Trap	(~ 2.5m)	<p>Water depths greater than 2.5m will restrict most rooted emergent and submerged aquatic macrophytes particularly in constructed wetlands designed for water quality control where water turbidity becomes a limiting factor. Typically only floating plants will occur in these zones. As for ponds, regular monitoring of these zones will be required to ensure undesirable weed species are detected and controlled.</p> <p>Where these zones are positioned at the inlet to a wetland they are the primary sediment traps for the treatment system so any vegetation that does happen to establish or develop will be regularly disturbed when sediment is being removed from the pond.</p>	<p><i>Myriophyllum, Potamogeton, Vallisneria, Nymphaea.</i></p> <p>Weed Risks: The likelihood of significant submerged plant growth in these zone is relatively low but the risk of floating weed invasion is very high. For example <i>Salvinia molesta, Eichhornia crassipes, Pistia stratiotes, Ipomea aquatica.</i></p>
Wetland Fringing Zones		<p>The edges and surrounding area of wetlands typically experience large variations in inundation depth, frequency and duration. The zone immediately above and below normal water level</p>	

		usually experiences the greatest variation. This zone commonly supports fringing marsh and swamp vegetation adapted to regular but short duration inundation. With increasing elevation inundation frequency and duration in particular decreases. Under these less restrictive conditions for plant growth a range of woody vegetation can develop. Typical examples are riparian and floodplain swamp forests.	
Fringing Marsh/Swamp	above NWL (~ 0.3m)	Hydrologically this zone has similar inundation depths as the Shallow Marsh zone but normally increased frequency and reduced duration. As a result there are a very great number of plants that can occur in this zone ranging from sedges and rushes through leafy herbs to woody shrubs and trees.	This zone can support a great number of species and suitable plants can be selected from the following genera, eg. <i>Cyperus</i> , <i>Eleocharis</i> , <i>Limnophila</i> , <i>Ludwigia</i> , <i>Polygonum</i> , <i>Pandanus</i> , <i>Eugenia</i> , <i>Barringtonia</i> .
Swamp Forest	above NWL (~ 0-1.5m)	Hydrologically this zone is very well watered with regular inundation periods but is also regularly drained well enough to support large woody vegetation. Tropical swamp forests are typically very diverse systems both floristically and structurally and dominated by small to medium sized trees.	This zone can support a great number of species and suitable plants can be selected from the following genera, <i>Eugenia</i> , <i>Dipterocarpus</i> , <i>Fagraea</i> , <i>Ficus</i> , <i>Ixora</i> , <i>Lithocarpus</i> , <i>Litsea</i> , <i>Pandanus</i> , <i>Podocarpus</i> , <i>Shorea</i> , <i>Tarena</i> , <i>Tristania</i> , <i>Xanthophyllum</i> .

## THE PUTRAJAYA LAKE

The lake is at the southern part of the wetland. About 60% of the lake water flow from the wetland and the remaining 40% is the direct discharge from bordering promenade. The 20 m width promenade is the buffer feature along the lake shorelines. The water surface area of the whole lake is about 400 hectares. The total volume of the whole lake water is about 23.5 million cubic meters and the water depth is in the range of 3 to 14 meters. The lake has been planned to cater for multi-functional uses, including recreation, fishing, water sports and water transport. The lake and its foreshores also form Putrajaya's most popular resource for informal recreation as a waterfront city.

The principle features of the lake are shown below.

<b>Principal Features of Putrajaya Lake</b>						
Catchments Area	Water Level	Surface Area	Storage Volume	Average Depth	Average Catchments Inflow	Average Retention Time
50.90 KM2	RL 21.00 M	400 ha (4 K M2 )	23.50 mil. M3	6.60 M	200 million liters	132 days

## **REGULATIONS, ENFORCEMENT AND CONTROL**

Formal regulations are required to enable the Corporation to have effective control over the lake en route for maintaining the lake in an acceptable condition as planned. The objectives of the regulations, control and enforcement are to ensure the management objectives mentioned above be achieved in a systematic and regulated manner.

Guidelines such as Lake Management guidelines, The Putrajaya Lake Use Master Plan, Environmental Management Guidelines, The Catchment Management Guidelines and others , which is related in one way or another to the overall lake and wetland management, had been developed and introduced by management of Putrajaya Corporation to cover a wide scope of concern.

Zoning of the lake and wetlands is an important start to control the possible activities that are allowed in or around the lake. The lake zoning system has been useful, particularly in guiding the appropriate uses and activities.

Activities that might adversely affect the quality and integrity of lake and wetlands, the general amenity of parks and open spaces, residential neighborhoods and government institutional areas are deemed as prohibited in the lake and wetlands area. Similarly, activities that cause damage to banks (e.g. as a result of wash of fast large craft) and the overall water quality of the lake are forbidden.

The rules provide control of all activities that are envisaged to be undertaken in the lake and wetlands. Several user guidelines such as Guidelines for Licensing of Motorized Leisure boats, Guidelines for Licensing of Fishing and Code of Practice for Boating will be published

for public use. Guidelines for the Registration of Non-Motorized Leisure Boats, guidelines for activities requiring permits and approval, such as fishing, will also be published for public use. The user guidelines are meant to supplement the rules and assist users in carrying out the activity within the confines of the law.

**OPERATION AND MAINTENANCE ACTIVITIES**

Operation and maintenance activities cover a wide portion of the overall management requirements. The maintenance scope within the lake and wetlands areas are as below :

**The Maintenance Areas and Scopes**

Maintenance Areas	Maintenance Scopes
The Wetland Cells	<ul style="list-style-type: none"> <li>• Flora</li> <li>• Fauna</li> <li>• Fish</li> <li>• Pest</li> <li>• Litter</li> <li>• Sediments</li> </ul>
The Water Supply	<ul style="list-style-type: none"> <li>• Water Quality Monitoring</li> <li>• Water Quantity Monitoring</li> <li>• Water Quantity Controlling</li> <li>• Water Quality Enhancement</li> </ul>
The Structures	<ul style="list-style-type: none"> <li>• Shorelines</li> <li>• Weirs</li> <li>• Inlet/Outlet</li> <li>• Pump</li> </ul>
The Laboratory	<ul style="list-style-type: none"> <li>• The Machines/Equipments</li> <li>• Analysis chemicals</li> <li>• Apparatus</li> </ul>
The Nursery	<ul style="list-style-type: none"> <li>• The Plant Species The Irrigation system</li> <li>• The Fertilizers</li> <li>• The Machines/Equipments</li> </ul>
The Assets, Conditions and Status	<ul style="list-style-type: none"> <li>• The Structures/Pumps/Buildings</li> <li>• The Machines/Equipments/Apparatus</li> </ul>

	<ul style="list-style-type: none"> <li>• The Plants/Birds/Fish/Aquatic life/Fauna</li> <li>• The Data and analysis</li> </ul>
The Activities	<ul style="list-style-type: none"> <li>• Enforcement and Security Navigation</li> <li>• Emergency Response</li> </ul>

## MONITORING EXERCISE

### Monitoring Programs

Monitoring programs is part of the management activities that is undertaken to ensure a fair assessment of the wetland functions in relation to its ecological and management requirements as well as confirming the water quality status of the lake. It is also done to measure the status of the operational objectives. The monitoring data is also important for management decisions and for future development program.

### Monitoring activities for the Putrajaya Wetland and Lake Management

MONITORING TYPE	COMPONENTS	REMARKS
The Wetland and Lake Ecology monitoring	Bird	<ul style="list-style-type: none"> <li>-Include migratory bird, water bird and the existing bird within the wetland and lake.</li> <li>-Include the bird family which is not expected in the area</li> </ul>
	Fauna	<ul style="list-style-type: none"> <li>-Wildlife community, its protection and survival</li> <li>-Include pest and other control of Undesirable Species</li> </ul>
Biological monitoring	Plant Management	<ul style="list-style-type: none"> <li>-Plant performance - plant nutrient uptake</li> <li>-Plant health and density</li> <li>-Pest Infestation</li> <li>-Weeds - aquatic and on land</li> <li>-Fertilizer and herbicides application</li> </ul>
	Fish	<ul style="list-style-type: none"> <li>-Control of undesirable species</li> <li>-Routine fish sampling and restocking</li> <li>-Stocking of endangered and rare species</li> <li>-Illegal fishing</li> </ul>
	Sediment	<ul style="list-style-type: none"> <li>-The quantity or volume of sediment</li> </ul>

		-trace pollutant content -Hydrographic and wetland depth survey
Water Quality monitoring	The Catchment	Water runoff quantity Water runoff quality Ground water quantity and quality
	Putrajaya area	-Water Runoff Quantity -Water Runoff Quality -The Wetland water quality -The Lake water quality
Other Management Purpose		Maintenance
	Education	Research, Community Awareness and Education, Tourism

## PERMISSIBLE ACTIVITIES



Lake Use Management Zone	Permissible Water Craft	Permissible Water Activities
Zone 1	No recreational vessels permitted.	No public activities permitted.
Zone 2	-Model yachts/model power boats -Sail boards -Pedal powered leisure craft -Canoes, kayaks -Row boats -Small electric powered boats	-Controlled water access -Model boat use -Small water craft hire and use -Fishing from boats -Foreshore fishing within designated locations Organised fishing - competitions, model boating or other

		environmentally appropriate -events
Zone 3	<ul style="list-style-type: none"> <li>-Canoes, kayaks, rowing skiffs, and dragon boats for sporting events.</li> <li>-Tour boats and Cruise boats. Vessels to comply with predetermined design and performance -criteria.</li> <li>-Water police and Emergency response boats.</li> <li>-Lake maintenance vessels.</li> </ul>	<ul style="list-style-type: none"> <li>-Aquatic sporting events with prior permit.</li> <li>-Tour and Cruise boat commercial operations by permit.</li> <li>-Foreshore fishing within designated areas.</li> </ul>
Zone 4	<ul style="list-style-type: none"> <li>-Canoes, kayaks, rowing skiffs, dragon boats for club activities and events.</li> <li>-Small powered boats complying with predetermined design and performance criteria.</li> <li>-Powered leisure boats complying with predetermined design and performance criteria.</li> <li>-Ferries and Tour boats complying with predetermined vessel design and performance criteria.</li> </ul>	<ul style="list-style-type: none"> <li>-Sports rowing and paddling training and events (permissible with a club permit but better suited to Zone 5 for other than competitions).</li> </ul>
Zone 5	<ul style="list-style-type: none"> <li>-Model yachts/model powerboats.</li> <li>-Pedal powered leisure craft.</li> <li>-Small yachts and sailboards.</li> <li>-Canoes, kayaks, row boats.</li> <li>-Rowing skiffs, dragon boats.</li> </ul>	<ul style="list-style-type: none"> <li>-Model sailing and power boating within designated areas.</li> <li>-Pedal powered leisure craft hire within designated areas.</li> <li>-Sailing within designated areas.</li> <li>-Leisure canoeing, kayaking and row boating hire.</li> <li>-Sports rowing and paddling training and competition events.</li> </ul>
Zone 6	<ul style="list-style-type: none"> <li>-Canoes, kayaks, row boats.</li> <li>-Small powered boats complying with predetermined design and performance criteria.</li> <li>-Powered leisure boats complying with predetermined design and performance criteria.</li> <li>-Marine police and Emergency response boats.</li> <li>-Lake maintenance vessels.</li> </ul>	<ul style="list-style-type: none"> <li>-No public access or recreational activities permissible within designated fish habitat sectors.</li> <li>-Leisure canoeing, kayaking and row boating.</li> <li>-Sports rowing and paddling training.</li> <li>-Small powered hire boating.</li> <li>-Powered leisure boating by hire - self-driven (by license) or professionally</li> </ul>

		<p>skipped.</p> <p>-Fishing from boats.</p> <p>-Foreshore fishing within designated areas.</p> <p>-Special fishing competitions by permit.</p>
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## PUTRAJAYA LAKE AND WETLAND MANAGEMENT & OPERATIONAL SYSTEM (PLWMOS)



The PLWMOS system is intended to serve as the main environmental database and spatial analytical tool for the current survey of hydrology, physico-chemical, and biotics parameters of Putrajaya lake and wetlands. The intended PLWMOS system will have functionalities for data entry, environmental modeling and online report submission and shall have the capability to be linked to the existing system (or systems) within CMC (e.g. EMMS). PLWMOS will also be designed as a knowledge-based decision support system particularly to serve as an early warning system to alert for potential environmental problems.

The main objectives of Putrajaya Lake and Wetland Management & Operational System (PLWMOS) system includes:

- To provide data entry module for scientists & technical consultants.
- To setup a centralized, easily accessible, and integrated environmental database management system.
- To develop monitoring & environmental assessment modules based on techniques and models within the scope as advised by the sectoral consultants
- To develop and provide means for internet based report submission and assessment module (data reports and results visualization).
- To develop an early warning system to alarm for potential environmental problems.
- For more details please click to <http://plwmos.ppj.gov.my>

Source: [http://www.ppj.gov.my/portal/page?\\_pageid=311,1&\\_dad=portal&\\_schema=PORTAL#1312](http://www.ppj.gov.my/portal/page?_pageid=311,1&_dad=portal&_schema=PORTAL#1312)